Date:

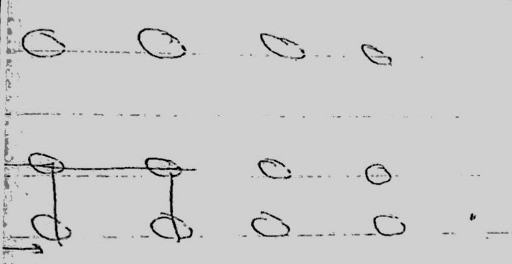
11/١٢ السبت III

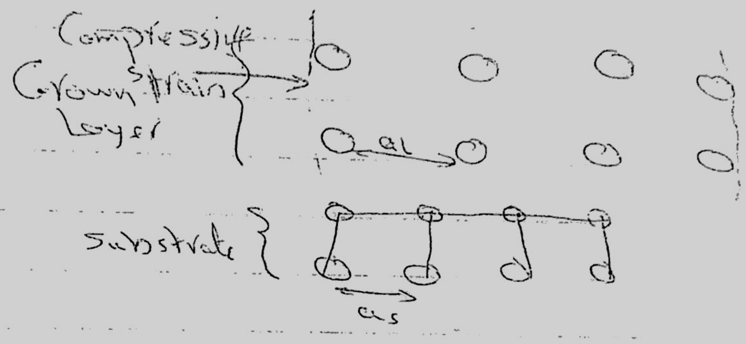
"Strained layer Epitaxy"

essive strain:-

s of grown layer adjust
selves to be matched
atoms of substrate

⇓





tion:- d(thickness of grown layer) < d_c

$d_c = \frac{a_s}{2|\epsilon|}$, $\epsilon = \frac{a_L - a_s}{a_L}$

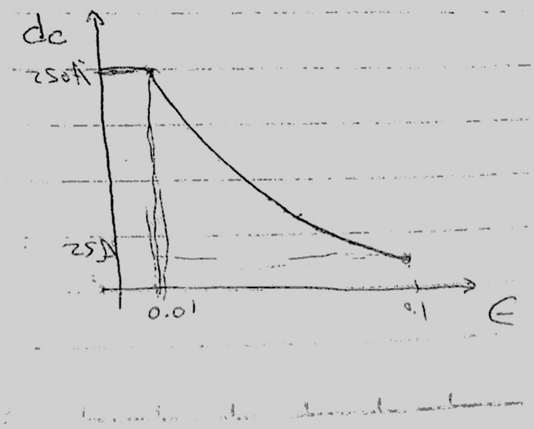
mismatch parameter

$\epsilon = 0.01$ $a_s = 5 Å$

$d_c = \frac{a_s}{2|\epsilon|} = \frac{5}{2*0.01} = 250 Å$

$\epsilon = 0.1$ $a_s = 5 Å$ $\longrightarrow a_L = \frac{5}{0.9} Å$

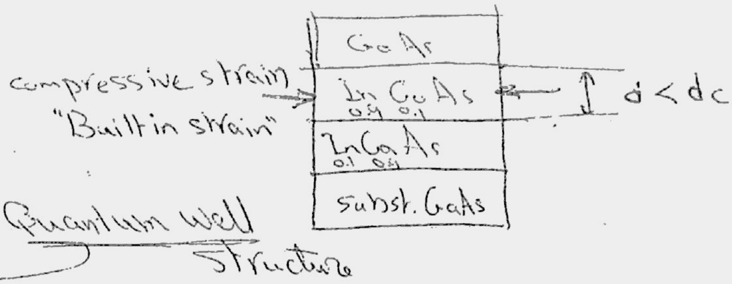
$d_c = \frac{5}{2*0.1} = 25 Å$



$In_xGa_{1-x}As / GaAs$

GaAs $\longrightarrow a = 5.65 Å$

InAs $\longrightarrow a = 5.87 Å$



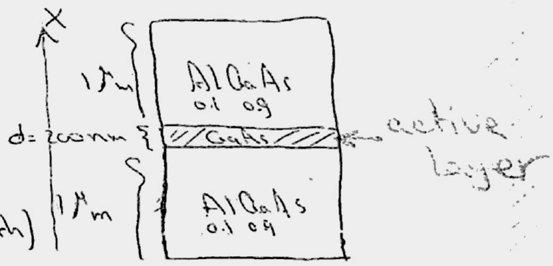
It will be strained Quantum well structure

As the thickness must be very small

Double Hetro Structure :- (Quantum well structure)

two semiconductor materials grown into a sandwich

* type 1: outer layers $\longrightarrow$ material has E_{g_1}
  & the sandwitched layer has $E_{g_2} < E_{g_1}$
  ex: $Al_xGa_{1-x}As$ / GaAs



$\rightarrow$ thickness $d < \Lambda$ (deBroglie wavelength)

$$\Lambda = \frac{2\pi}{K}$$

$$K = \frac{P}{\hbar} = \frac{\sqrt{2m^* E_{K.E.}}}{\hbar}$$

$$E_{K.E.} = \frac{1}{2} m v^2 = \frac{P^2}{2m^*}$$

$$P = \sqrt{2m^* E}$$

$$\therefore \Lambda = \frac{2\pi\hbar}{P} = \frac{h}{\sqrt{2m^* E_{K.E.}}}$$

$E_{K.E.}$ = thermal energy | $T = 300\,K$

$$E_{K.E} = 0.025\ eV$$

$$m_c^* = 0.067\, m_o = 0.067 * 9.1 * 10^{-31}$$

$$\Lambda = 300\,\text{Å}$$

Band Diagram

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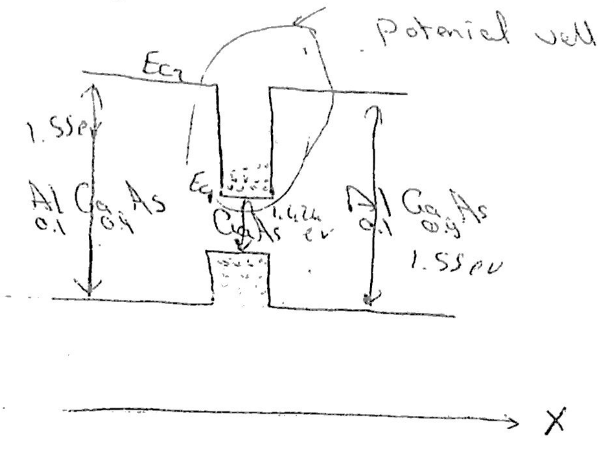
$24 + 1.247x$, $x < 0.45$

$= 0.1$

1.55 eV



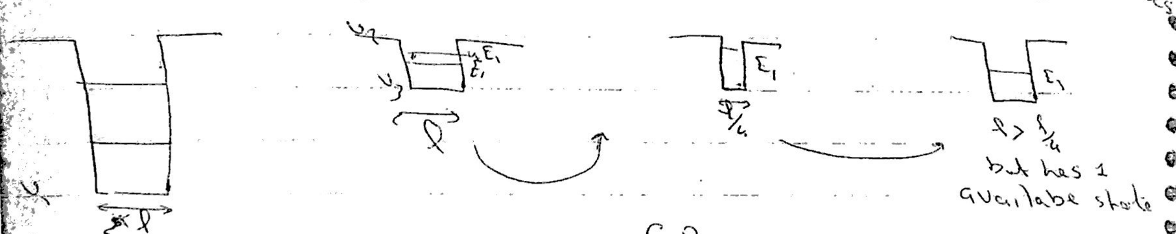
$= 1.424 \text{ eV}$

Finite Potenial well

$$E_{C2} > E_n > E_{C1}$$

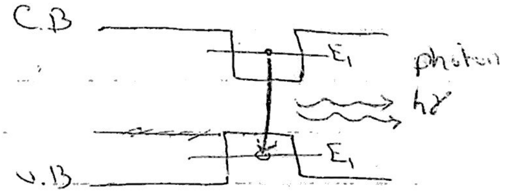
energy states ... thickness الـ

...kness of active material) decreases → (E_1) the first state ... well shifts up & distance between successive states increases



...ate in every band → 1-wave length of photon

app:- laser Diode



$E_{C1} = 0.67\, E_g \longrightarrow E_{g\,AlGaAs} - E_{g\,GaAs} = 1.55 - 1.424 = 0.126$

$E_{V1} = 0.33\, E_g$

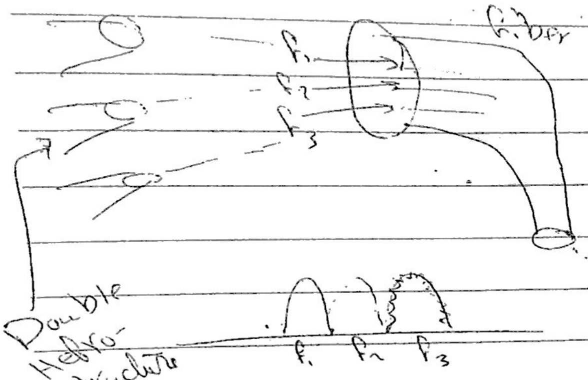
$E_g = 1.55 - 1.424 = 0.126$

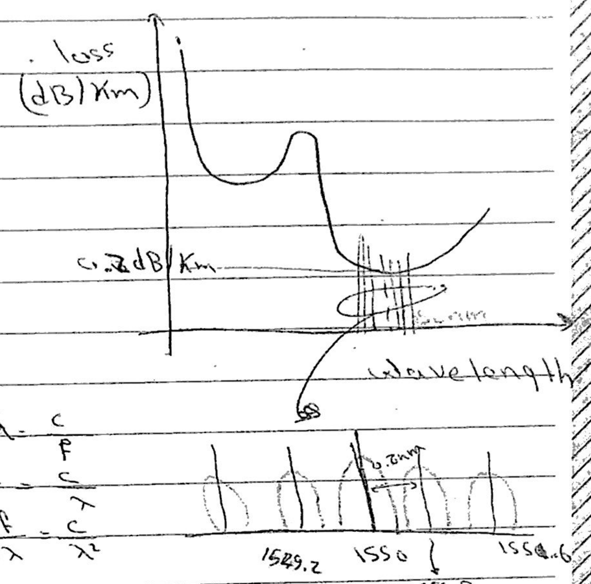
$E_{C1} = (0.67 * 0.126) + 1.55 =$

$E_{V1} = 1.424 - (0.33 * 0.126) =$

* Objective of Laser Diode:-

Dense Wavelength Division Multiplexing





عن طريق تغيير d أقدر أغيره

يعني أقدر أعمل optical sources

الفرق بينهم 100GHz ~~…~~ اللي عايزاه

$$\lambda = \frac{c}{f}$$

$$f = \frac{c}{\lambda}$$

$$\frac{df}{d\lambda} = \frac{c}{\lambda^2}$$

$$df = \frac{c}{\lambda^2} d\lambda$$

$\lambda = 1550$, $d\lambda = 0.8$

0.8 nm $\longrightarrow$ 100 GHz

Date :

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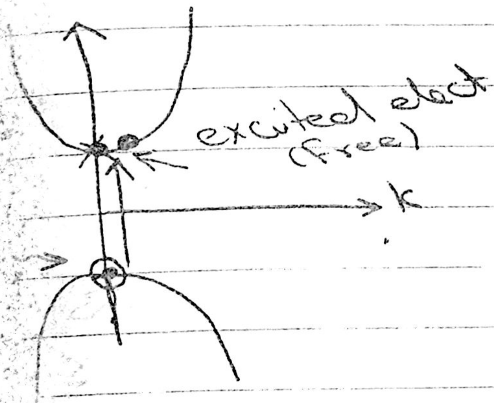
Interaction of light with matter

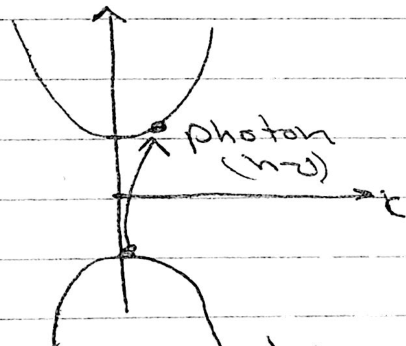
sorption



word transition

ical detect

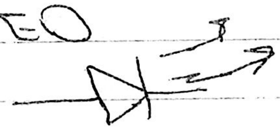
② spontenous Emission



downword trans

App

LED



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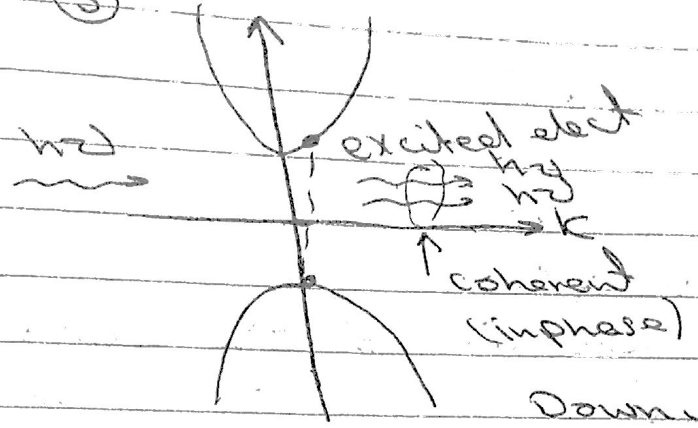


Downword trans

APP

LO

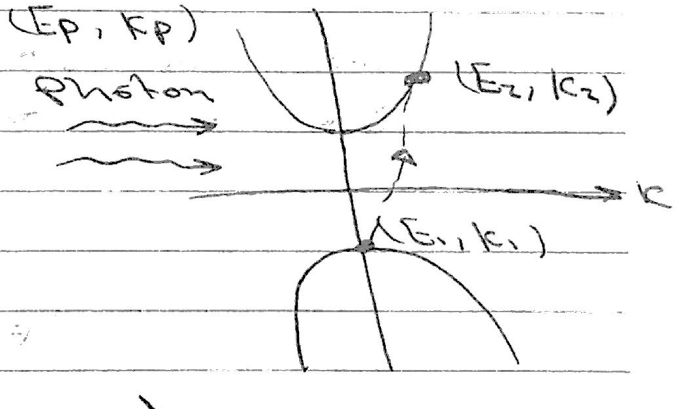
Transition

* conservation of energy

$E_2 = E_1 + E_p$

E_2 ↑ Final energy of elect

E_1 ↑ initial energy of elect



* conservation of momentum

$P_2 = P_1 + P_p$

$\cancel{\hbar} k_2 = \cancel{\hbar} k_1 + \cancel{\hbar} k_p$

$k_2 = k_1 + k_p$

$E_p = h\nu = \frac{hc}{\lambda}$ $\lambda \rightsquigarrow 0.5\,\mu m \to 1.5\,\mu m$

$E_g = \frac{1.24}{\lambda_g}$ $E_g = 1.24\ eV$

يعني بدنا نستغل ph كـ

ال sem mat فقط

$1eV < E_g < 3eV$

E_g ↓ semicond

(2)

of Pho can allow transi
...iconal material

$k_2 = k_1 + k_p$ — photon — $k = \frac{2\pi}{\lambda}$

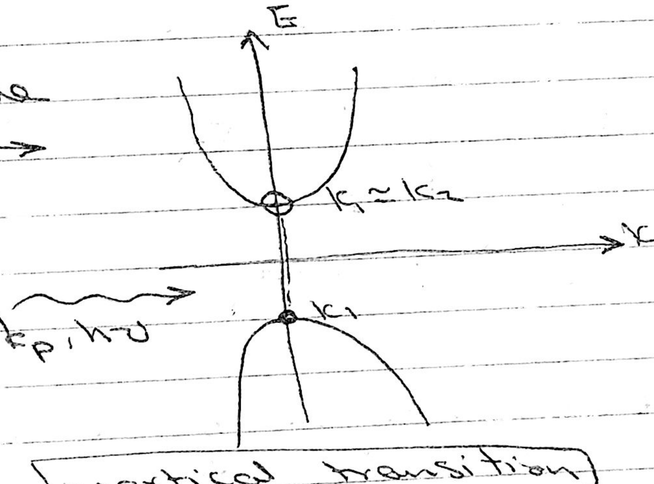
...vector — wave vector $= \frac{2\pi}{1 \times 10^{-6}} = 2\pi \times 10^{6}\ m^{-1}$

$\frac{2\pi}{100 A^\circ} = 2\pi \times 10^{8}$

$k_2 - k_1 \simeq 0$

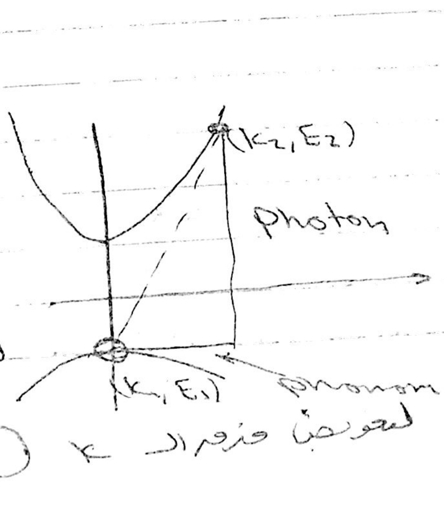
...mentum of photon is neglected
... momentum of electron

selection rule
$\Delta k = 0$

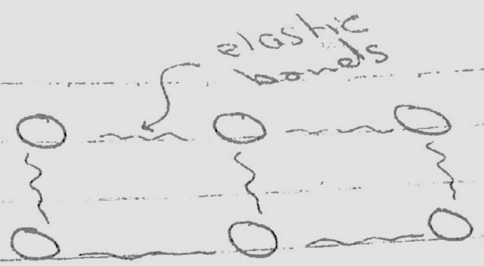


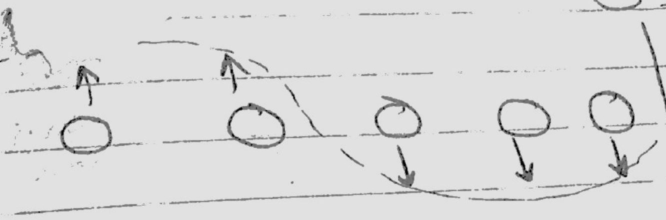
$\boxed{\text{vertical transition}}$
= pho assisted transition

...lique transition
...يعني ph مش هيتم ال
...hoton, phonon)
...m
... of Lattice
...ibration

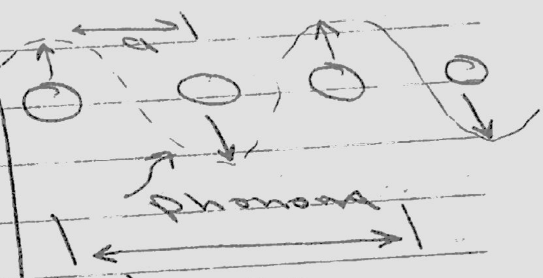


phonon assisted transi ③





Acoustic phonon



$\lambda_{ph} = 2a$

optical phonon

$f_{optical\ ph} > f_{acoustic\ ph}$

$\lambda_{optical\ ph} < \lambda_{acoustic\ ph}$

$k_{optical\ ph} = \dfrac{2\pi}{\lambda_{optical\ ph}}$ for ex $= \dfrac{2\pi}{10\text{Å}} = 2\pi \times 10^{9}$

$Energy_{phon} \simeq$ Small $\simeq$ 10 meV → 70 meV
$\simeq$ Thermal energy

	Photon	Phonon
	Quantum of light	Quant of lattice vibrat
gy	1 eV → 3 eV	10 meV → 70 meV
	0.5 μm → 1.5 μm	10 Å → 100 Å
	high energy	Low energy
	no momentum	high moment

Apply Boltzman App

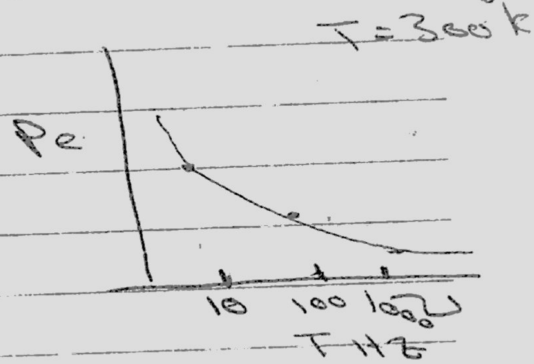
$$|E - E_f| >> kT$$

$$P_e = e^{-(E_2 - E_f)/kT} * e^{(E_1 - E_f)/kT}$$

$$= e^{-(E_2 - E_1)/kT}$$

$$P_e = e^{-h\nu/kT}$$

0.025 meV



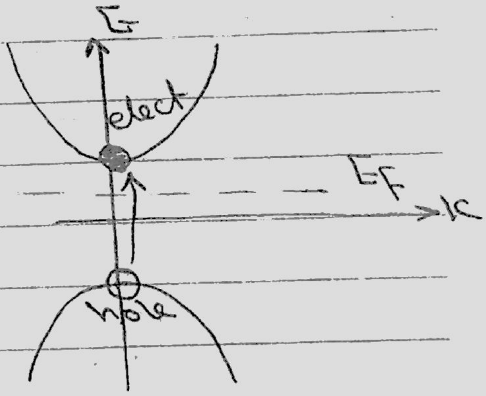
$\nu \uparrow \qquad P_e \downarrow$

$P_e \simeq$ zero

$* \; P_{ab} = ??$

✓ elect (E_1) exists in V.B

✓ vacant state (E_2) exists in C.B



$$P_{ab} = f(E_1)\,[1 - f(E_2)]$$

$$= \frac{1}{e^{(E_1 - E_f)/kT} + 1}\left[1 - \frac{1}{e^{(E_2 - E_f)/kT} + 1}\right]$$

$$= \frac{1}{e^{(E_1 - E_f)/kT} + 1}\left[\frac{e^{(E_2 - E_f)/kT}}{e^{(E_2 - E_f)/kT} + 1}\right]$$

Boltzman Approx

$$|E - E_f| >> kT$$

$P_{ab} \simeq 1$ $\qquad \boxed{P_{ab} > P_e}$